Check List the journal of biodiversity data
NOTES ON GEOGRAPHIC DISTRIBUTION

First record of a breeding site of *Ara militaris mexicanus* (Ridgway, 1915), Military Macaw (Psittacidae), in the Alto Balsas Poblano Region, Mexico

Leopoldo Daniel Vázquez-Reyes[1], Víctor Hugo Jiménez-Arcos[2], Patricia Ramírez-Bastida[1], Jorge Tanit Rodríguez-Malacara[3], Ana María Contreras-González[4], Oscar Salomón Sanabria-Urban[4], Francisco Alberto Rivera-Ortiz[3]

1 *Carrera de Biología, Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Tlalnepantla de Baz, Estado de México, México*
2 *Laboratorio de Herpetología, Vivario, Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Tlalnepantla de Baz, Estado de México, México*
3 *Laboratorio de Ecología Molecular y Evolución, Unidad de Biotecnología y Prototipos, Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Tlalnepantla de Baz, Estado de México, México*
4 *Laboratorio de Ecología, Unidad de Biotecnología y Prototipos, Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Tlalnepantla de Baz, Estado de México, México*

Corresponding author: *Francisco Alberto Rivera-Ortiz (francisco.rivera@iztacala.unam.mx)*

Abstract. We report a new breeding site of *Ara militaris mexicanus* (Ridway, 1915), Military Macaw, in the state of Puebla in the Alto Balsas river basin, Mexico. The breeding site is in the Cañón Grande area along the Nexapa River. Observed temporality and breeding behaviors agree with the recorded breeding season of this species in Central Mexico. Notably, the region has no current designation as a protected natural area for conservation. We recommend collaboration with the local community to initiate efforts towards designate the Alto Balsas river basin as a protected natural area.

Key words. Conservation, tropical dry forest, Nexapa River, breeding site, breeding behaviors, Santa María Cohetzala

Vázquez-Reyes LD, Jiménez-Arcos VH, Rodríguez-Malacara JT, Contreras-Gonzalez AM, Sanabria- Urbán OS, Ramírez-Bastida P, Rivera-Ortíz FA (2024) First record of a breeding site of *Ara militaris mexicanus* (Ridgway, 1915), Military Macaw (Psittacidae), in the Alto Balsas Poblano Region, Mexico. Check List 20 (4): 996–1003. https://doi.org/10.15560/20.4.996

INTRODUCTION

Ara militaris (Linnaeus, 1766), Military Macaw, has a wide and disjunct distribution, ranging from northern Mexico to South America. Its primary habitat includes ravines, canyons and slopes within tropical dry forests, including deciduous, semideciduous forest, and tropical oak forest (Rivera-Ortiz et al. 2013). According to the geographical distribution, three subspecies of the *Ara militaris* complex are recognized: *A. m. militaris* (Linnaeus, 1766), occurring in Venezuela, Colombia, Ecuador, and Peru; *A. m. bolivianus* (Reichenow, 1908), distributed in Bolivia and Argentina; and *A. m. mexicanus* (Ridway, 1915), found in Mexico (Juniper and Parr 1998; Dehasque 2016). Two primary lineages are identified within the complex: *A. m. mexicanus* and *A. m. militaris–A. m. bolivianus*. Historical isolation between the ancestral populations of these lineages is suggested by the discontinuous geographical distribution of this species (Rivera-Ortíz et al. 2023).

Rivera-Ortíz et al. (2023) proposed elevating the subspecies *A. m. mexicanus* to a full species, as *A. mexicanus*, although conclusive evidence is lacking. Therefore, *A. m. mexicanus* should be retained as a subspecies of *A. militaris*. For these reasons, we attribute the breeding population in this note to the subspecies *A. m. mexicanus*. This subspecies has an approximate length of 67 cm and displays body plumage ranging from olive to bright green, with a matte green tone on the nape (Howell and Webb 1995; Macedo 2007). The flight feathers are blue on the upper part and olive-yellow on the interior part. The mantle is pale blue, with the upper tail covert feathers red and the lower cover feathers turquoise blue (Gaucin 2000). The forehead exhibits a crimson red tone, the auricular region varies from white to pink, featuring lines of small black and red feathers, and the beak is black (Juniper and Parr 1998; Dehasque 2016; Ortega 2024; Figure 1).

Historically in western Mexico, *A. militaris mexicanus* extended continuously from Sonora to Chiapas,

OPEN ACCESS

Academic editor: Jonas Rosoni
Received: 25 January 2024
Accepted: 24 July 2024
Published: 15 July 2024

Copyright © The authors. This is an open-access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0)

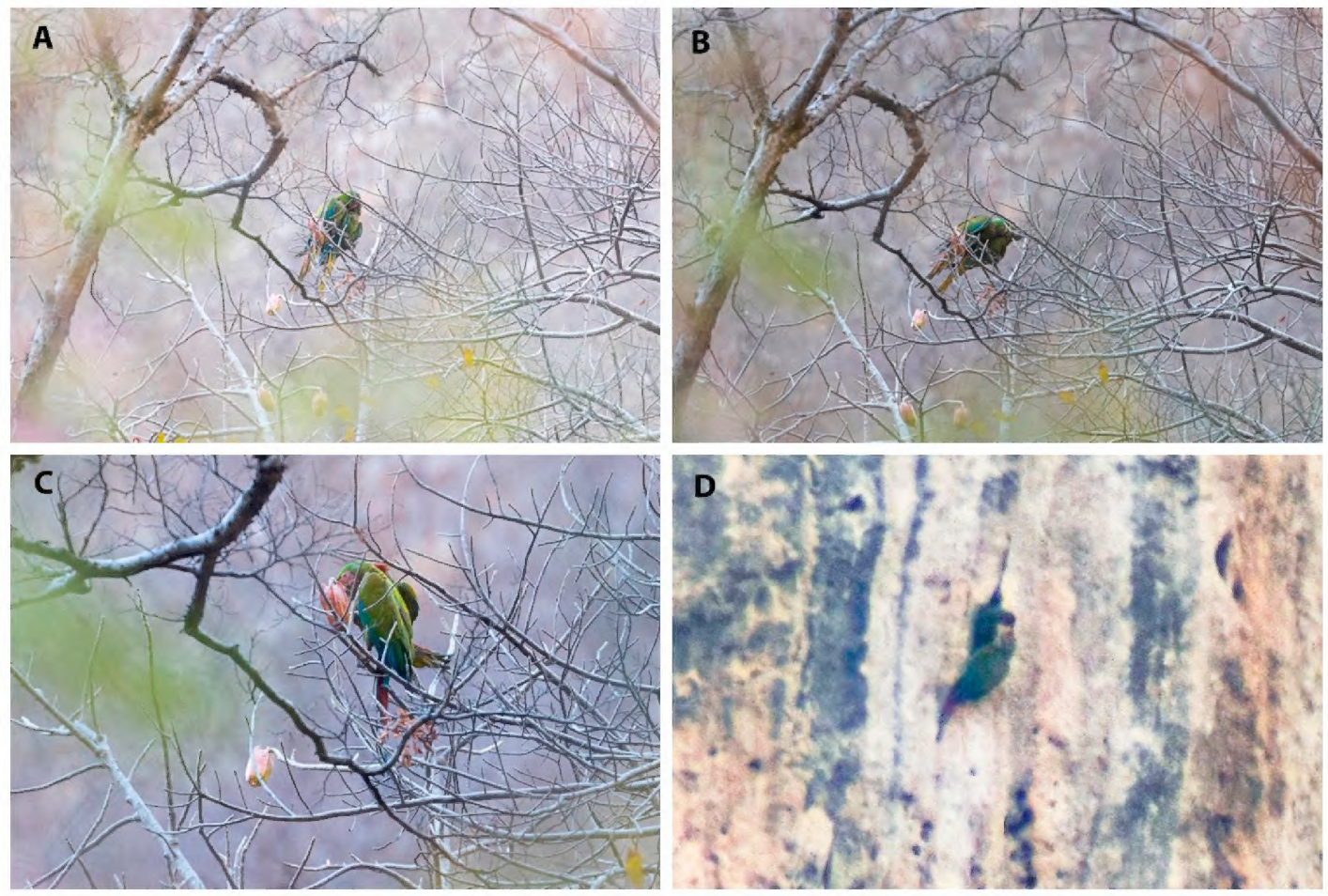

Figure 1. Observation of *Ara militaris mexicanus* with breeding activity in the Cañón Grande in the Paraje del Reloj, Santa María Cohetzala Puebla. **A, B.** Courtship. **C.** Mating. **D.** Incubation of eggs.

including the Balsas basin influence area in Michoacán, Guerrero, Puebla, and Oaxaca. Additionally, it is found in the eastern mountainous regions of Nuevo León, Tamaulipas, San Luis Potosí, and Querétaro (Iñigo-Elías 1999). However, its distribution and populations are currently in decline due to unsustainable capture for the illegal bird trade and habitat fragmentation resulting from land-use changes. Specifically, the habitat of this species in Mexico experiences an annual deforestation rate of 3.27–5.21%. Additionally, habitat loss has intensified in recent years of approximately 270,000 km^2 of potential habitat; by 2010, the loss had reached 150,000 km^2 and increased to 160,000 km^2 by 2016 (Rivera-Ortiz et al. 2013; Marín-Togo et al. 2012). These factors have led to the local extirpation of *A. militaris* over much of its range (Loza 1997; Rivera-Ortiz et al. 2008; Ríos-Muñoz and Navarro-Sigüenza 2009; Marín-Togo et al. 2012). Consequently, *A. militaris* is now listed under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2013), and as Vulnerable according to the International Union for Conservation of Nature (IUCN 2022), and in Mexico, it is considered as an endangered species (SEMARNAT 2019).

Ara militaris undertakes altitudinal movements that range from 600 to 2200 m in elevation, and it has been suggested that these movements are influenced by variations in the abundance of food resources (Contreras-González et al. 2009) and the northern region of western Mexico by cooler temperatures in fall and winter (Nocedal et al. 2006). Its diet encompasses fruits, seeds, leaves, buds, and stems, making it a highly specialized species, as it consumes 10–23% of the available plant resources (Iñigo-Elías 1999; Contreras-González et al. 2009). This species exhibits gregarious nesting behavior, typically selecting cavities in vertical karstic walls or tree cavities with a diameter at breast height greater than 60 cm (Carreón 1997; Gómez 2004; Nocedal et al. 2006; Rivera-Ortíz et al. 2008, 2013).

Before 1999, the state of Puebla was not considered to be within the historical or potential distribution of *A. militaris* in Mexico, despite some unverified reports in the southern portion of Puebla (Arizmendi and Valiente-Banuet 1999). However, between 2008 and 2010, Salazar et al. (2010) documented the first sightings of the species in the state, with an average of six individuals recorded in Cerro Colorado Tehuacán, Puebla (150 km from our study area). They also recorded macaws to the south of Puebla, bordering the state of Oaxaca, in the vicinity of Teotitlán de Flores Magón, about 180 km from our study area (Salazar et al. 2010). It is noteworthy that within the Tehuacán-Cuicatlán Biosphere Reserve, located between Puebla and Oaxaca, approximately 190 km from our study area, exists a documented breeding population in Cañon del Sabino with an average of 80 individuals of *A. militaris* (Dirección de la Reserva de la Biosfera Tehuacán-Cuicatlán 2001; Rivera-Ortíz et al. 2008; Contreras-González et al. 2009). Additionally, 45 km from our study area in the Santa Cruz Achichiplilco in the municipality of Teotlalco, western Puebla, Hernández-Castán et al. (2012) reported an average of 36 macaws bordering the Sierra de Huautla Biosphere Reserve in the state of Morelos (Urbina-Torres et al. 2009) (Figure 2).

Since 2006, records of *A. militaris* have been documented in the Alto Balsas basin, which includes parts of the state of Guerrero, more than 20 km to west of southeastern Puebla (Jiménez-Arcos et al. 2012; Vázquez-Reyes et al. 2018). Jiménez-Arcos et al. (2012) reported a breeding colony with an average abundance of 23 individuals in the Cañon Xicuhuetztlán of Cerro del Tecaballo, Papalutla in Guerrero. Vázquez-Reyes et al. (2018) conducted a survey on *A. militaris* habitat conservation in the Alto Balsas basin in Guerrero, estimating an abundance of 100 individuals in the region (Naturam Sequi 2015, 2016). They also identified probable roosting and feeding areas near the locality of Santa María Cohetzala, Puebla,

approximately 20 km from the Papalutla breeding colony (Figure 2).

In this study, we present, for the first time, evidence of the presence and establishment of a new breeding population of *A. militaris* in the state of Puebla within the Alto Balsas basin river. In addition, we include data spanning from 2016 to 2023, accompanied by detailed observations of their natural history.

METHODS

Our records were made in Santa María Cohetzala, located in the Alto Balsas basin in the southwestern portion of the state of Puebla, Mexico. The area is characterized by having rugged terrain with substantial elevated landforms and extensive ravines, intersected by the Nexapa and Atoyac rivers (Figure 2). The elevation varies from 700 to 1900 m a.s.l. The region has a warm subhumid climate, with an average annual temperature of 26 °C and an annual precipitation ranging of 600–800 mm (García 1998). The predominant vegetation type is tropical dry forest, including deciduous and semi-deciduous woodlands (Martínez-Gordillo et al. 1997) (Figure 3).

Five exploration and observation routes were surveyed, using existing trails in the tropical dry forest on Tecaballo Mountain and in the subdecidous tropical forest along the Nexapa River, each route with an average duration of 8 h. The total area explored was 5 km^2, which included 3.5 km^2 in the deciduous forest and 1.5 km^2 in the subdeciduos forest. The routes were chosen based on previous studies by Naturam Sequi (2015, 2016) and local residents, who reported the presence of *A. militaris* in the area. The first route, in Peña del Sol, was surveyed on 12 December 2016 and had a length of 6 km. The second route, in Peña del Sol and Peña del Reloj in the Cañón Grande on Tecaballo Mountain, was surveyed on 12 February 2020 and had a route length of 8 km. The third route was surveyed on 6–7 March 2022 in Peña del Reloj and Cañón Grande and had a route length of 9 km. The fourth route, towards the upper part of the Cañón Grande in the Tecaballo Mountain, was surveyed on 5–7 June 2023, with the aim of locating viewpoints that would

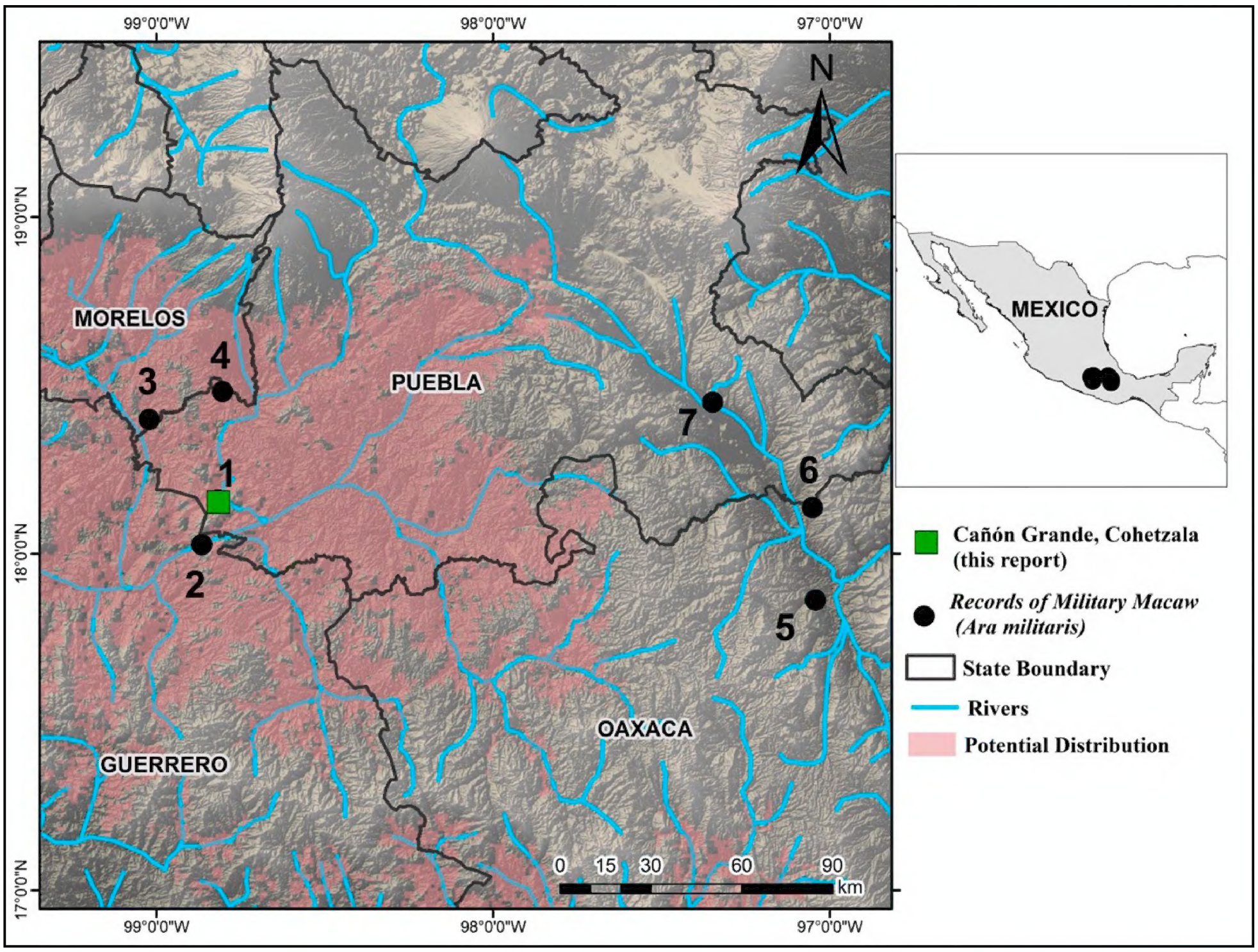

Figure 2. Records of *Ara militaris mexicanus*: 1 = Santa María Cohetzala Puebla, 2 = Papalutla Guerrero, 3 = Rancho Viejo Morelos, 4 = Teotlalco Puebla, 5 = Santa María Tecomavaca Oaxaca,6 = Teotitlan de Flores Magón Puebla, 7 = Tehuacán Puebla. The red area indicates the potential distribution model recognized for *Ara militaris mexicanus* (from Navarro-Sigüenza et al. 2018).

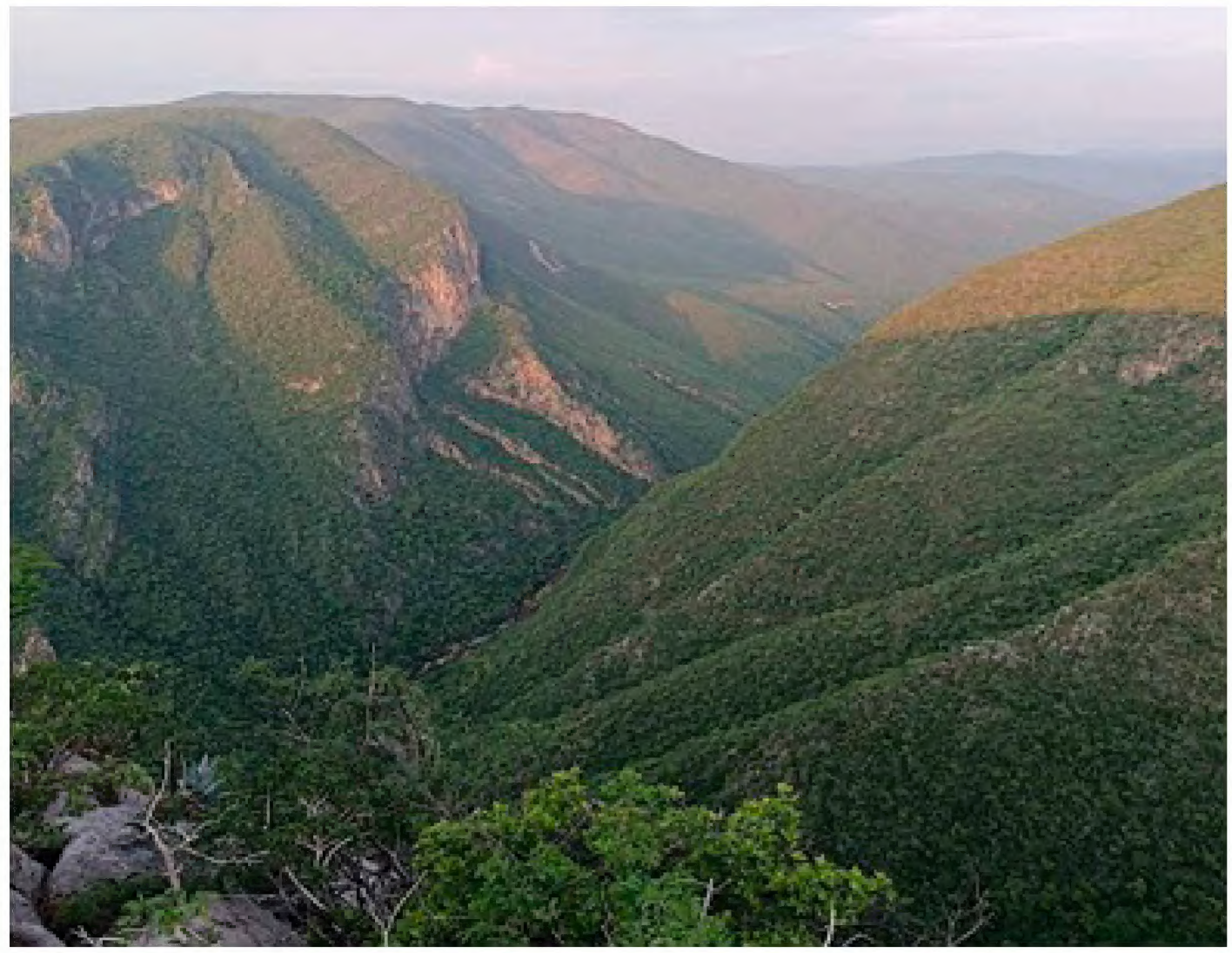

Figure 3. Cañón Grande where *Ara militaris mexicanus* was recorded, Sierra del Tecaballo, Santa María Cohetzala, Puebla.

provide better visibility of the canyon walls and *A. militaris* individuals, had a route length of 12 km. Finally, the fifth route, in Peña del Sol, was surveyed on 21–23 May 2024 and had a route length of 10 km, and the search was specifically for cavities used as nests. In each route there were five observers and two local guides (Table 1). During the exploration trips, natural history data were recorded, such as vegetation type, geographical coordinates, and the activities of *A. militaris* individuals, including foraging and breeding behavior. Photographic evidence was captured.

RESULTS

***Ara militaris mexicanus* (Ridgway, 1915)**
Figure 3

New records. MEXICO – Puebla • Santa María Cohetzala, Nexapa river, Peña del Sol, Peña del Reloj, Cañón Grande; 18.1936°N, 098.8226°W – 18.1530°N, 098.8153°W – 18.1531°N, 098.8161°W; 700–850 m elevation, 12.XII.2016, 12.II.2020, 06–07.III.2022, 06.VI.2023; Vázquez-Reyes LD., Jímenez-Arcos VH., Rivera-Ortíz FA. obs.

Identification. The species was morphologically identified through observations, photographic documentation, vocalizations, direct sightings (Figure 1), and verification by specialists in Psittacidae who are co-authors (FARO, LDVR, and AMCG).

Table 1. Record and activity of Military Macaw (*Ara militaris mexicanus*) in Santa María Cohetzala, Puebla.

Date (d/m/y)	Location	Georeference	No. of individuals	Activity/time
12/12/2016	Peña del Sol	18.1763°N, 098.8174°W	6	Flying/10:00
12/02/2020	Peña del Reloj Peña del Sol	18.1530°N, 098.8158°W 18.1625°N, 098.8205°W	10	Flying/10:00
06/03/2022	Peña del Reloj Peña del Sol	18.1544°N, 098.8158°W 18.1591°N, 098.8177°W	20	Cortege, copulation and flying/13:00 and 16:00
07/03/2022	Peña del Reloj	18.1530°N, 098.8153°W	18	Flying/06:00
06/06/2023	Cañón Grande	18.1502°N, 098.8201°W	16	Flying, perched and entering cavities/17:00 and 19:30
07/06/2023	Cañón Grande	18.1502°N, 098.8201°W	20	Flying, perched and cavities coming out/05:30 and 06:14
22/05/2024	Peña del Sol	18.1591°N, 098.8177°W	10	Egg incubation/11:00 a 17:00

Remarks. The first record of the macaws was from 12 December 2016, at 10:00 h by one of us (LDVR), who noted three pairs flying over the Nexapa River and perching on the emerging trees towards the northwest of the Peña del Sol site. It is possible that the birds were heading towards the Cañón Xicuhuetztlán in Papalutla, Guerrero. On 12 February 2020, at 14:00 h, 10 macaws were observed flying in circular movements over the Peña del Sol site along the course of the Nexapa River. They were heading towards Peña del Reloj, where they were seen entering the Cañón Grande (Table 1). Only their vocalizations could be heard, as the canyon was inaccessible to us, preventing further data recording.

On 22 March 2022, at 12:00 h, four individuals of were observed flying over the course of the Nexapa River at the entrance of the Cañón Grande. They were feeding on the fruit of the Bonete Tree, *Jacaratia mexicana* A.DC. for approximately 30 min. After eating, two of these macaws flew and entered the Cañón Grande, while the other two macaws perched on a Parota Tree, *Enterolobium cyclocarpum* (Jacq.) Griseb. and engaged in courtship behavior for 5 min. Subsequently, they returned to the Bonete Tree, continued courtship for a couple of minutes, and were observed mating (Figure 1). At 13:00 h, they also entered the Cañón Grande. Later, at 16:00 h, a flock of 16 macaws was recorded, heading towards the Cañón Grande. On the same day, a walk through the canyon, six individuals were observed, and their vocalizations heard. On 7 March 2022, at 06:00 h, nine pairs of *A. militaris* were recorded as they exited the Cañón Grande. They were heading northwest, making circular movements over the Nexapa River, and then headed towards the Tecaballo Mountain (Table 1). Once again, the vocalizations of the macaws were heard from within the canyon.

On 6 June 2023, 16 macaws were recorded entering the Cañón Grande between 17:00 h and 19:30 h. They engaged in flights within the canyon, with some perching on the Cuajiote Colorado Tree, *Bursera morelensis* Ramírez and the Cacaloxuchil Tree, *Plumeria rubra* L. Others macaws entered the cavities in the walls of the Cañón Grande. On 7 June 2023, at 5:30 h, macaw vocalizations were heard within the canyon. At 6:15 h, a flock of 20 individuals emerged, spreading out over the course of the Nexapa River (Table 1). Cavities used to roost by the macaws were marked with guano on the walls of the Cañón Grande and identified, although their use for nesting were not identified. On 22 May 2024, two cavities occupied by *A. militaris* with reproductive activity were recorded. We observed that one individual, a male, arrived to feed another individual, the female, in the cavity. This occurred in both cavities throughout the day, indicating egg incubation (Figure 1).

DISCUSSION

Our results on the natural history and breeding biology of the *Ana militaris mexicanus* provide important information about the first record a breeding site of this species in the state of Puebla, Mexico. Breeding activities, including mating and courtship, strongly suggest that the Cañón Grande in the Peña del Reloj on Tecaballo Mountain represents a breeding site (Forshaw 2006).

In the semi-arid seasonal environments of central Mexico, the nesting season of *A. m. mexicanus* is known to start in March with courtship and mating, ending in late September with the first flight of fledglings (Rivera-Ortíz et al. 2008; Jiménez-Arcos et al. 2012; Vázquez-Reyes 2018). We recorded breeding activity in March, such as courtship and mating, as well as cavity use in June, which coincides with the patterns observed in the dry forests of central Mexico (Rivera-Ortíz et al. 2008; Jiménez-Arcos et al. 2012). The increase in the number of individuals in March likely corresponds to the onset of the breeding season (March–September) with the arrival of the first pairs. However, we note that our data are not consistent throughout the year, emphasizing the need for a permanent monitoring program of the population to document accurate patterns that may vary over time (Jiménez-Arcos et al. 2012).

The nearest breeding site of *A. m. mexicanus* to Santa María Cohetzala, Puebla, is in Papalutla, Guerrero, approximately 20 km away (Jiménez-Arcos et al. 2012). A more distant population is in Santa María Tecomavaca, Oaxaca, 190 km away, located within the Tehuacán-Cuicatlán Biosphere Reserve (Rivera-Ortíz et al. 2008). Additional records of *A. m. mexicanus* in the region have been documented in Higuera, Teotlalco, Puebla (39 km away from our records) (Hernández-Castán et al. 2012), Cerro Colorado, Puebla (150 km away), Teotitlán de Flores Magón (180 km away) (Salazar et al. 2010), and Guerrero (216 km away) (Almazán-Núñez and Nova Muñoz 2006).

Our observations in Santa María Cohetzala suggest that a metapopulation of *A. m. mexicanus* inhabits the Alto Balsas region, which is supported by field evidence from conservation projects (Naturam Sequi, 2015, 2016) and ongoing monitoring data, which show fluctuating abundance between Papalutla and Santa María Cohetzala breeding sites and foraging areas in response to resource availability and even stochastic events. For instance, a census on 29 January 2024, recorded 46 individuals at the Xicuhuetztlán Canyon in Papalutla, while the Cañón Grande in Santa María Cohetzala had 25 individuals on 26 February 2024. Unfortunately, there was a forest fire near Cañón Grande on 12 March 2024 which disturbed nearby foraging areas. Subsequently, on 24 March 2024 at least 80 individuals were recorded in the roosting census at Xicuhuetztlán Canyon, likely due to macaws seeking refuge and foraging areas after the fire. This behavior aligns with the species' capacity for movement between nesting, resting, and foraging areas; this species can move up to 25 km per day, and it has an average home movement range of 87 km^2 (Juárez et al. 2012).

Our results may be found to be of importance in determining demographics and migratory movements

between populations and for determining population connectivity through genetic and genomic analyses (landscape genetics) of the metapopulation (Ramírez-Albores 2016). Population genetics and phylogeography of *A. m. mexicanus* in the Sierra Madre Occidental and Sierra Madre del Sur show that these populations maintain genetic flow (Rivera-Ortíz et al. 2017; Rivera-Ortíz et al. 2023).

The breeding site of *A. m. mexicanus* in Santa María Cohetzala is within the Important Bird Area (IBA) MX264 Papalutla-Tecaballo, as recognized by BirdLife International (2021). Furthermore, this IBA is acknowledged as within a Priority Region for Conservation in Guerrero, according to CONANP (2021). However, the distribution of this *A. m. mexicanus* population does not overlap with any natural protected area, despite its close proximity (37 km) to the Sierra de Huautla Biosphere Reserve, where *A. m. mexicanus* has been recorded at Rancho Viejo locality of Morelos (Urbina-Torres 2017). Regardless, these area designations are considered insufficient to reduce biodiversity loss in the region (Vázquez-Reyes 2018). This region is among those in which the least conservation efforts have been invested within Mexico.

Unfortunately, the breeding site of *A. m. mexicanus* in Santa María Cohetzala faced significant disturbances in 2016 and 2017 due to an uncontrolled wildfire, during which the State of Puebla deployed helicopters and helibuckets within the Cañón Grande (residents of Santa María Cohetzala pers. comm.). Despite such disturbance, the tropical dry forest in the area remains relatively unaffected, making it a potential area for *A. m. mexicanus* conservation.

Tecaballo Mountain, with its two breeding sites of *A. m. mexicanus*, one in Guerrero and one in Puebla, should be a focal point for conservation plans (Jiménez-Arcos et al. 2012). However, the conservation of the *A. m. mexicanus* population requires several important environmental policy actions and decisions. First, is necessary guarantee the protection and restoration of the forest habitats critical for foraging, roosting, and breeding of this species. However, this task is complicated by administrative complexities stemming from the macaw's distribution across Puebla and Guerrero states (Vázquez-Reyes 2018). Solid knowledge of the ecology of *A. m. mexicanus* in Santa María Cohetzala and on Tecaballo Mountain is of paramount importance. This will enable the formulation of effective conservation strategies in the region (De la Parra-Martínez et al. 2015).

Establishing biodiversity protection areas including two states has been successfully done in Mexico, as exemplified by the Tehuacán-Cuicatlán Biosphere Reserve which spans the states of Puebla and Oaxaca. This reserve has effectively allocated targeted funding for conservation focused on forest habitat of *A. m. mexicanus*. Indeed, *A. m. mexicanus* now acts as an umbrella species for biodiversity protection within the Tehuacán-Cuicatlán Biosphere Reserve (Vinculación Interdiciplinaria para el Desarrollo Ambiental y lo Social 2018). Again, coordinated efforts among Puebla, Guerrero, and the national environmental authorities are required. Fortunately, there important advances have already been made in documenting endemic biodiversity and threats to it, providing solid evidence to support an eventual designation of a federal protected natural area in the region (Vázquez-Reyes et al. 2018).

The protection of natural systems hinges on the establishment and development of environmental protection plans that encourage the active participation of residents in the conservation of vegetation cover and associated animal components (Vázquez-Reyes 2018). Reports like which are crucial for catalyzing the political will of authorities to allocate necessary budget and management efforts toward achieving the conservation of *A. m. mexicanus* and its habitat in the Alto Balsas region.

ACKNOWLEDGEMENTS

We express our heartfelt gratitude to the communal authorities and residents of the community of Santa María Cohetzala, Puebla, as well as to all the individuals who provided valuable assistance during the fieldwork. We acknowledge the reviewers and the subject editor for their enriching comments and suggestions. This work was supported by UNAM-DGAPA-PAPIIT IA207821 and IA204324 (Francisco A. Rivera-Ortíz), as well as IA210820 and IA208124 (Leopoldo D. Vázquez-Reyes). We also extend our appreciation to CONANP PROCER/DRCEN/003/2015 and PROCER/DRCEN/06/2016 (LDV-R, Naturam Sequi), BioPic (Biosphera Picture A.C.), the Mexican Alliance of Photography for Conservation (AMFC) for providing the photographs for Figure 1A–C, and to Jorge Tanit Rodríguez-Malacara for providing the photograph in Figure 1D.

ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

No ethical statement is reported.

Funding

This study was financially supported by UNAM-DGAPA-PAPIIT (IA207821, IA204324, IA210820, IA208124).

Author contributions

Conceptualization: LDVR, FARO. Funding acquisition: LDVR, FARO. Investigation: VHJA, AMCG, JTRM, OSSU. Methodology: LDVR, FARO, PRB. Resources: LDVR, FARO. Project administration: LDVR, FARO. Writing – original draft: LDVR, VHJA, FARO. Writing – review and editing: LDVR, VHJA, JTRM, AMCG, OSSU, PBR, FARO.

Author ORCID iDs

Leopoldo Daniel Vázquez-Reyes https://orcid.org/0000-0002-3344-4594
Víctor Hugo Jiménez-Arcos https://orcid.org/0000-0001-6948-0071
Jorge Tanit Rodríguez-Malacara https://orcid.org/0009-0009-8957-7984
Ana María Contreras-González https://orcid.org/0000-0003-4509-7865
Oscar Salomón Sanabria-Urban https://orcid.org/0000-0002-4079-498X
Patricia Ramírez-Bastida https://orcid.org/0000-0003-1260-3768
Francisco Alberto Rivera-Ortíz https://orcid.org/0000-0002-5487-4817

Data availability

All data that support the findings of this study are available in the main text.

REFERENCES

Almazán-Núñez RC, Nova-Muñoz O (2006) La guacamaya verde (*Ara militaris*) en la Sierra Madre del Sur, Guerrero, México. Huitzil 7 (1): 20–22.

Arizmendi MC, Valiente-Baunet A (1999) AICA 26 Valle de Tehuacán-Cuicatlán. In: Arizmendi MC, Márquez-Valdelamar L (Eds.) Áreas de importancia para la conservación de las aves en México. CIPAMEX Press, Distrito Federal, México, 315–316.

BirdLife International (2021) Important Bird Area factsheet: Papalutla, Sierra de Tecaballo. http://datazone.birdlife.org/site/factsheet/papalutla-tecaballo-iba-mexico. Accessed on: 2023-4-15.

Carreón GG (1997) Estimación poblacional, biología reproductiva y ecología de la nidificación de la Guacamaya verde (*Ara militaris*) en una selva estacional del oeste del estado de Jalisco. Bachelor´s thesis, Universidad Nacional Autónoma de México, Distrito Federal, México, 79 pp.

CITES (Convention on International Trade in Threatened and Endangered Species of Wild Fauna and Flora) (2013) Appendix I. https://cites.org/eng/app/appendices.php. Accessed on: 2023-4-20.

Contreras-González AM, Rivera-Ortíz FA, Soberanes-González C, Valiente-Banuet A, Arizmendi MC (2009) Feeding ecology of Military Macaws (*Ara militaris*) in a semi-arid region of central Mexico The Wilson Journal of Ornithology 121 (2): 384–391. http://dx.doi.org/10.1676/08-034.1

CONANP (Comisión Nacional de Áreas Naturales Protegidas) (2021) Áreas Naturales Protegidas Federales de México. http://sig.conanp.gob.mx/website/pagsig/listanp/. Accessed on: 2023-4-30.

De la Parra-Martínez SM, Renton K, Salinas-Melgoza A, Muñoz-Lacy LG (2015) Tree-cavity availability and selection by a large-bodied secondary cavity-nester: the Military Macaw. Journal of Ornithology 156: 489–498. https://doi.org/10.1007/s10336-014-1150-9

Dehasque M (2016) Applied Conservation Genomics of Military Macaws (*Ara militaris*). PhD thesis, Universiteit Antwerpen, Antwerp, Belgian, 52 pp.

Dirección de la Reserva de la Biosfera Tehuacán-Cuicatlán (2001) Registro de Guacamaya Verde (*Ara militaris*) en los cañones del Río Sabino y Río Seco, Santa María Tecomavaca, Oaxaca. México. Huitzil 2: 18–20.

Forshaw JM (2006) Parrots of the world. Princeton University Press. Princeton, USA, 320 pp.

García E (1998) Climas: clasificación de Koppen, modificado por García, escala 1:1000000. CONABIO, Distrito Federal, México. http://geoportal.conabio.gob.mx/metadatos/doc/html/clima1mgw.html. Accessed on: 2023-5-3.

Gaucin RN (2000) Conservation biology of the Military Macaw (*Ara militaris*) in the basement of Sotano del Barro, Queretaro. SNIB-CONABIO, Distrito Federal, Mexico, 38 pp. http://www.conabio.gob.mx/institucion/proyectos/resultados/InfL204.pdf. Accessed on: 2023-5-28.

Gómez GJ (2004) Ecología reproductiva y abundancia relativa de la Guacamaya verde en Jocotlán, Jalisco, México. Bachelor's thesis, Universidad Nacional Autónoma de México, Distrito Federal, México, 75 pp.

Hernández-Castán J, Villordo-Galván JA, Cano-García BI, Gaspariano-Martínez E, Rodríguez-Cantalapiedra P (2012) Registro de guacamaya verde (*Ara militaris*) en la UMA Santa Cruz Achichipilco, municipio de Teotlalco, Puebla, México. Huitzil 13: 130–136.

Howell SNG, Webb SA (1995) Guide to the birds of Mexico and northern Central America. Oxford University Press, Oxford, UK, 337 pp.

Íñigo-Elías EE (1999) Las guacamayas verde y escarlata en México. Biodiversitas 25: 7–11.

IUCN (International Union for Conservation of Nature) (2022) The International Union for Conservation of Nature Red List of Threatened Species. https://www.iucnredlist.org. Accessed on: 2023-4-11.

Juárez M, Marateo G, Grilli PG, Pagano L, Rumi M, Silva-Croome M (2012) Estado del conocimiento y nuevos aportes sobre la historia natural del guacamayo verde (*Ara militaris*). El Hornero 27 (1): 5–16.

Jiménez-Arcos VH, Santa Cruz-Padilla SA, Escalona-López A, Arizmendi MC, Vázquez L (2012) Range expansion and reproductive colony of the Military Macaw (*Ara militaris*) in the upper Balsas basin, Guerrero, México. Revista Mexicana de Biodiversidad 83: 864–867. https://doi.org/10.7550/rmb.27460

Juniper T, Parr M (1998) Parrots: a guide to the parrots of the world. Yale University Press, New Haven, USA, 584 pp.

Loza CA (1997) Patrones de abundancia, uso de hábitat y alimentación de la Guacamaya Verde (*Ara militaris*) en la Presa Cajón de Peña, Jalisco, México. Bachelor's thesis, Universidad Nacional Autónoma de México, Distrito Federal, México, 76 pp.

Macedo RG (2007) Biología reproductiva de la Guacamaya verde (*Ara militaris*) en la cañada oaxaqueña, dentro de la Reserva de la Biosfera Tehuacán-Cuicatlán. . Master's thesis. Instituto Politécnico Nacional, Oaxaca, Oaxaca, 58 pp.

Marín-Togo MC, Monterrubio-Rico TC, Renton K, Rubio-Rocha Y, Macías-Caballero C, Ortega-Rodríguez JM, Cancino-Murillo R (2012) Reduced current distribution of Psittacidae on the Mexican Pacific coast: potential impacts of habitat loss and capture for trade. Biodiversity and Conservation 21: 451–473. https://doi.org/10.1007/s10531-011-0193-y

Martínez-Gordillo M, Valencia-Avalos S, Calónico-Soto J (1997) Flora Papalutla, Guerrero y de sus alrededores. Anales del Instituto de Biología, Serie Botánica 68: 107–133.

Navarro-Sigüenza AG, Gordillo-Martínez A, Peterson AT, Ríos-Muñoz CA, Gutiérrez-Arellano CR, Méndez-Aranda D, Kobelkowsky-Vidrio T, Sánchez-Ramos LE (2018) *Ara militaris* (guacamaya verde). Distribución potencial, escala: 1:1300000. edición: 1. Museo de Zoología Alfonso L. Herrera, Facultad de Ciencias, Universidad Nacional Autónoma de México. Proyecto: JM071, Mapas de distribución de las aves terrestres nativas de Mesoamérica. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO). Ciudad de México, México. http://geoportal.conabio.gob.mx/metadatos/doc/html/ami071dpgw.html. Accessed on: 2023-2-20.

Naturam Sequi (2015) Prospección de la Guacamaya verde en el Alto Balsas. Comisión Nacional de Áreas Protegidas. Programa de Conservación de Especies en Riesgo, Informe Final, Naucalpan de Juárez, Estado de México, 35 pp.

Naturam Sequi (2016) Conservación del hábitat de la Guacamaya verde en el Alto Balsas. Comisión Nacional de Áreas Protegidas. Programa de Conservación de Especies en Riesgo, Informe Final, Naucalpan de Juárez, Estado de México, 38 pp.

Nocedal J, Sierra D, Arroyo S (2006) Are Green Macaws really tropical birds? Nesting and feeding in temperate pine-oak forest of southern Durango, México. In: IV North American Ornithological Conference, Veracruz, México, 238–242.

Ortega CE (2024). Filogeográfia de la Guacamaya verde (*Ara miliatris mexicanus*) en México y sus implicaciones para la conservación. Bachelor's thesis, Universidad Nacional Autónoma de México, Tlalnepantla de Baz, México, 38 pp.

Ramírez-Albores JE (2016) La guacamaya verde (*Ara militaris*) en la Sierra Gorda de Guanajuato, México. Acta Zoológica Mexicana 32: 182–185. https://doi.org/10.21829/azm.2016.322946

Ríos-Muñoz CA, Navarro–Sigüenza AG (2009) Efectos del cambio de uso de suelo en la disponibilidad hipotética de hábitat para los psitácidos de México. Ornitología Neotropical 20 (4): 491–509.

Rivera-Ortiz FA, Contreras-González AM, Soberanes-González CA, Valiente-Banuet A, Arizmendi MC (2008) Seasonal abundance and breeding chronology of the Military Macaw (*Ara militaris*) in a semi–arid region of central Mexico. Ornitología Neotropical 19: 255–263.

Rivera-Ortíz FA, Oyama K, Ríos-Muñoz CA, Solórzano S, Navarro-Sigüenza AG, Arizmendi MC (2013) Habitat characterization and modeling of the potential distribution of the Military Macaw (*Ara militaris*) in Mexico. Revista Mexicana de Biodiversidad 84: 1200–1215. https://doi.org/10.7550/rmb.34953

Rivera-Ortiz FA, Solorzano S, del Coro Arizmendi M, Davila-Aranda P, Oyama K (2017) Genetic diversity and structure of the Military Macaw (*Ara militaris*) in Mexico: implications for conservation. Tropical Conservation Science 10: 1–12. https://doi.org/10.1177/1940082916684346

Rivera-Ortíz FA, Sanabria-Urbán S, Prieto-Torres DA, Navarro-Sigüenza AG, Arizmendi MDC, Oyama K (2023) Phylogeography of *Ara militaris* (Military Macaw): implications for Conservation. Diversity 15 (10): 1035. https://doi.org/10.3390/d15101035

Salazar TJM, Bonilla-Ruiz C, Ximello-Olguín FX (2010) Primer registro de Guacamaya verde (*Ara militaris*) en el municipio de Tehuacán, Puebla, México. Mesoamericana 14: 59–66.

SEMARNAT (Secretaría de Medio Ambiente y Recursos Naturales) (2019) Modificación del Anexo Normativo III, Lista de especies en riesgo de la Norma Oficial Mexicana NOM-059-SEMARNAT, Protección ambiental– Especies nativas de México de flora y fauna silvestres. Diario Oficial de la Federación, Ciudad de México. https://www.dof.gob.mx/nota_detalle.php?codigo=5578808&fecha=14/11/2019#gsc.tab=0. Accessed on: 2024-2-20.

Urbina-Torres F, Romo de Vivar-Álvarez C, Navarro-Sigüenza AG (2009) Notas sobre la distribución de algunas aves de Morelos, México. Huitzil 10: 30–37.

Urbina-Torres F (2017) Especies de pericos (psitácidos) en Morelos. Inventio 13 (29): 39–46.

Vázquez-Reyes LD, Jiménez-Arcos VH, SantaCruz-Padilla SA, García-Aguilera R, Aguirre-Romero A, Arizmendi MC, Navarro-Sigüenza AG (2018) Aves del Alto Balsas de Guerrero: diversidad e identidad ecológica de una región prioritaria para la conservación. Revista Mexicana de Biodiversidad 89: 873–897. https://doi.org/10.22201/ib.20078706e.2018.3.2314

Vinculación Interdiciplinaria para el Desarrollo Ambiental y lo Social (2018) Acciones de conservación de la guacamaya verde en Tahuacán-Cuicatlán . Comisión Nacional de Áreas Protegidas. Programa de Recuperación y Repoblación de Especies en Riesgo, Informe Final, Oaxaca de Juárez, Oaxaca, 38 pp.